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Investor attention to salient features of analyst forecasts

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Investor attention to rounding as a salient forecast feature

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Abstract

Prior research suggests that, when making economic decisions, investors focus on subsets of more salient information. We extend this research by examining variation in investor response to a salient feature in analyst forecasts. We focus on the *roundness* of analyst forecasts as a salient signal of imprecision. We examine whether: 1) investors notice rounding even though it is binary and has potentially limited information content, 2) investor reaction to rounding is affected by its repetition, and 3) investor reaction to rounding varies by investor type. We document a weaker market reaction to rounded compared to non-rounded forecasts, consistent with investors using rounding as an indicator of less precise forecasts. Investor response to rounding is more pronounced in the presence of multiple rounded forecasts, simultaneously disclosed in analyst reports, and is primarily attributed to less sophisticated investors. We also provide evidence on investors' delayed assimilation of the information content in rounded forecasts subsequent to the forecast announcement date. Our results shed light on the scope of limited investor attention.

Keywords: limited investor attention, rounding, investor sophistication, repetition

JEL Classifications: *G14, G29, M41*

Investor attention to rounding as a salient forecast feature

1. Introduction

In this paper we examine variation in investors' response to a salient feature of analyst forecasts.[1] Evidence exists that investors are subject to attentional constraints when making economic decisions and as a result focus on subsets of publicly available information that are more salient, i.e. that tend to stand out and are easier to process.[2] Such selective attention to salient stimuli can be economically justified if time and attention are costly (Hirshleifer and Teoh, 2003). The literature to date focuses largely on limited investor attention to information released by firms, e.g. in earnings announcements and annual reports. A number of studies examine how the form of information released by analysts, being key intermediaries in capital markets, affects investors' abilities to assimilate earnings-related information (Clement and Tse, 2003; Gleason and Lee, 2003). The purpose of this study is to build on the latter evidence and examine variation in selective attention to a salient feature of analyst outputs. We focus on the *roundness* of analyst earnings-per-share (EPS) forecasts (hereafter referred to as *rounding*). Rounding manifests itself in forecasts that end in zero or five (e.g. $1.00, $1.50, $1.15). We choose rounding because it allows us to assess variation in investor attention to salience along three dimensions. First, we examine whether investors notice rounding as a salient forecast feature even if it is less informative than other forecast characteristics (e.g. forecast horizon, prior forecast accuracy, firm experience, forecast frequency, forecast timeliness, broker size). Second, we examine whether investor reaction to the salient forecast feature is affected by the repetition of this feature. Finally, we study the variation in investor attention to the salient forecast feature by investor type. Our analysis contributes to the literature on limited attention by shedding light on the scope of investors' attentional constraints.

Rounding represents a common type of measurement error in discrete quantitative data based on subjects' responses or observers' assessments. It reflects a cognitive process associated with less effort, uncertainty and imprecision (e.g. Huttenlocher, Hedges, and Bradburn, 1990; Roberts and

[1] The salience of a stimulus is its prominence, tendency to 'stand out' or its degree of contrast with other stimuli in the environment (Hirshleifer and Teoh, 2003, p.342).
[2] See Kahneman (1973), Nisbett and Ross (1980), Fiske and Taylor (1991), etc.

Brewer, 2001). Consistent with this notion, prior studies examining rounding in analyst forecasts document that rounded forecasts are issued by less informed and lower effort analysts, and are, on average, less accurate (Herrmann and Thomas, 2005). Dechow and You (2012) further show that investors appreciate, to a degree, the rounding bias on analyst forecasts, and perceive rounded forecasts as a more noisy measure of the market's expectation of earnings at earnings announcements.

We examine whether and to what extent investors pay attention to the rounding feature of analyst forecasts at forecast revision announcements, given all other informative forecast characteristics that they can observe. The characteristics that investors use in appraising forecast quality include: analysts' prior forecasting ability, brokerage firm affiliation, forecast frequency, forecast timeliness, firm-specific experience, firm and industry expertise (Park and Stice, 2000; Gleason and Lee, 2003). On the one hand, rounding is likely to be less informative to investors than other forecast attributes because, unlike these other characteristics, rounding is binary. Apart from revealing that a forecast is less accurate, the rounding feature has no further implication for the relative imprecision of the forecast.[3] On the other hand, the rounding feature of a forecast is more salient and easy-to-process characteristic and may thus serve as a summary costless indicator of less precise forecasts. Information that is easier to extract (e.g., more salient) tends to be more fully reflected in judgments or prices (Bloomfield, 2002). Also prior empirical studies show that information presented in salient form is absorbed more easily than information that is less salient and more difficult-to-process (Daniel, Hirshleifer and Teoh, 2002; Hirshleifer and Teoh, 2003; Song and Swartz, 2008; Huang, Nekrasov, and Teoh, 2013; Ali and Gurun, 2009, Palomino, Renneboog, and Zhang, 2009). The salience or form of information can also affect the perceptions of *non-informationally* equivalent disclosures (Hirshleifer and Teoh, 2003).[4] There is also

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[3] Dechow and You (2012) examine the decision to round as a trade-off between costs and benefits and show that analysts engage in rounding when the penny digit of the forecast is of less economic significance. Their interpretation of these findings is that a rounded forecast is a simple and more easily observable proxy for a more noisy measure of the market's expectation of earnings. We argue that a rounded forecast is less informative than other forecast attributes because, while it signals that it is a noisy measure of the market's expectation of earnings, it does not signal the *extent* of the noise due to its binary nature.

[4] For instance, previous literature has shown that investors respond to re-announcements of irrelevant, redundant or old information when this information is presented in a more salient way (e.g., Schrand and Walther, 2000). Schrand and Walther (2000) show that managers strategically announce prior period information separately to influence investors' perceptions of the benchmark used for evaluating current period earnings. Hand (1990) finds that investors respond to re-announced gains from debt equity swaps in earnings announcements and the gains are associated with mean abnormal returns. Other studies examining the effect of limited attention and salience on

evidence that individuals are prepared to pay for useless information, even when this is transparently the case (Powdthavee and Riyanto, 2015). Therefore, we hypothesize that, despite the binary nature and potentially limited informativeness of rounding, investors are likely to respond to it when appraising analyst forecasts. We state the first hypothesis in the null form:

H_1: *Investors do not respond to rounding in analyst forecasts.*

Investors' response to the information contained in a forecast characteristic is measured by the degree to which this characteristic contributes to explaining return responses. Clement and Tse (2003) show that, holding the magnitude of the revision constant, investor response increases with broker size, forecast frequency and timeliness. If, in line with prior evidence, rounding is negatively associated with forecast precision then, investors' response to rounding at revision announcements would translate into a weaker reaction to the information of rounded (i.e. less precise) forecasts compared to non-rounded (i.e. more precise) forecasts, holding the magnitude of the revision constant.

The next testable prediction relates to the repetition of the rounding feature. Previous rounding literature has focused on rounding at a given point in time (Herrmann and Thomas, 2005; Zhou, 2010; Dechow and You, 2012). Given prior evidence on analyst performance persistence (Sinha, Brown, and Das, 1997; Mikhail, Walther and Willis, 2004; Bradshaw, Brown and Huang, 2013, etc.), it is likely that analysts who issue rounded forecasts do so consistently over time and across forecasting horizons. Analyst reports usually contain the previous forecast issued for the same year, the current forecast, and a one-year-ahead forecast. The inclusion of the previous forecast in analyst reports is warranted by the need to explain to investors the changes that have taken place in the firm or its environment since the previous forecast issuance and the impact of these changes on firm valuation. The publication of a one-year-ahead forecast in analyst reports is a regular analyst output that reveals the analyst view of the firm's future prospects.[5] The current, previous and one-year-ahead forecasts are usually presented side by side as illustrated by the sample analyst report in Appendix B. The issuance of multiple rounded

stock prices include Klibanoff, Lamont, and Wizman 1999), Cooper, Dimitrov and Rau, (2001), Huberman and Regev (2001).

[5]Asquith, Mikhail and Au, (2005) document that 99.1% of the analyst reports they examine provide an EPS forecast and 95.3% of these reports contain forecasts for at least one subsequent year.

forecasts that are simultaneously disclosed and observed by investors at no extra cost is likely to reinforce the salience of the rounding feature. Hillstrom (2000) provides experimental evidence that the repetition of a feature makes salient features even more salient. In line with this, a number of studies capture the prominence of a disclosure item in analyst reports by its repetition (e.g. Asquith, Mikhail and Au, 2005; Previts, Previts, Bricker, Robinson and Young, 1994). To the extent that investor attention is drawn to the higher salience of simultaneously disclosed multiple rounded forecasts, we expect that investors place more importance on rounding as an indicator of imprecise forecasts when there are multiple rounded forecasts in the analyst report (i.e. when a rounded forecast is issued alongside a rounded previous forecast and a rounded one-year-ahead forecast). If rounding repetition is perceived as more salient and reinforces the idea that rounded forecasts are less precise, we expect that, holding the magnitude of the revision constant, the market reaction to repeated rounding will be even weaker than to one-time rounding. We state this hypothesis in the null form:

H_2: *There is no difference in investors' response to repeated and one-time rounding in analyst forecasts.*

Our final prediction is related to more sophisticated and less sophisticated investors' use of rounding. Existing experimental evidence on limited attention suggests that limited attention may affect both naïve and sophisticated investors' interpretation of financial information (Hopkins, 1996; Hirst and Hopkins, 1998; Libby, Bloomfield and Nelson, 2002, etc.). However, evidence exists that small traders are less thorough in their interpretation of earnings-related disclosures (Bhattacharya, 2001; Allee, Bhattacharya, Black and Christensen, 2007; Battalio and Mendenhall, 2005, Blau, DeLisle and Price, 2015). Less sophisticated investors tend to be also more susceptible to salience and ease of processing effects than more sophisticated investors (Miao, Teoh and Zhu, 2013).[6] This evidence suggests that more sophisticated investors may monitor additional informative and more costly-to-process analyst characteristics in responding to forecast revisions compared to less sophisticated

[6]Miao et al. (2013) document that more sophisticated investors discount accruals relative to cash flows regardless of whether a statement of cash flows (SCF) is provided or not, whereas less sophisticated investors discount accruals relative to cash flows only when SCF is provided.

investors. This might diminish the relative importance more sophisticated investors place on forecast rounding and increase the weight they place on other less salient but informative forecast characteristics. In addition, if less sophisticated investors are also less busy, i.e. their attention may be less fully occupied than that of more sophisticated investors. Lavie's (2005) load model suggests that individuals whose attention is not fully occupied (loaded) may be more prone to distraction by salient stimuli.[7] Investors' response to rounding may therefore vary with the level of investor sophistication. We expect that less sophisticated investors take into account the rounding feature of analyst forecasts to a greater extent compared to more sophisticated investors when responding to analysts' forecasts. Holding the magnitude of the revision constant, this would translate into a weaker response to rounding by less sophisticated than by more sophisticated investors. The third hypothesis, stated in the null, is the following:

H_3: *Investors' response to rounding in analyst forecasts does not vary with the level of investor sophistication.*

In the empirical tests, we first examine whether investors use rounding as a salient forecast feature associated with imprecision, i.e. react less strongly to information in rounded compared to non-rounded forecasts. We then examine whether investor attention to rounding increases with the recurrence of rounding instances within the analyst report. Third, we examine whether investors' response to rounding in analyst forecasts varies with the level of investor sophistication. We use institutional ownership or institutional turnover as proxies for investor sophistication (Bonner, Walther, and Young, 2003; Hilary and Hsu, 2013, Collins, Gong and Hribar, 2003). Our results show that investors react less strongly to rounded than to non-rounded forecasts, consistent with investors using rounding as an indicator of less precise forecasts. We document even weaker investor reaction to

[7] Lavie's (2005) load model suggests that interference from less relevant stimuli (e.g. rounding) is more likely to occur when attention is not fully occupied (loaded).

rounding when multiple rounded forecasts are simultaneously disclosed in analyst reports and show that investors' response to rounding is primarily attributed to less sophisticated investors.

We complete our analysis by investigating whether rounding is associated with price adjustments following the forecast revision announcement. If investors' use of rounding, and especially of repeated rounding, deters them from fully appraising all remaining informative cues, there may be subsequent price adjustments reflecting delayed assimilation of the information content in rounded forecasts. We test this assertion by examining whether the rounding indicator can predict one-year-ahead size-adjusted returns. We find that rounding and, to a greater extent repeated rounding help explain cross-sectional variation in future stock returns after controlling for revision quantity, revision quality (e.g. forecast innovation), analyst coverage and systematic risk factors (size, book-to-market and momentum). This evidence supports the idea of investors' susceptibility to the salience of rounding and their relative detraction from more subtle analyst characteristics at the revision announcement. We conduct a number of robustness tests to ensure our results are not affected by the anticipation of a rounded actual EPS, firm characteristics that determine rounding (e.g. firm complexity, see Dechow and You, 2012), analyst characteristics, broker firm characteristics, and concurrent confounding events during the revision announcement window.

The remainder of the paper is organized as follows. Section 2 discusses the research design. Section 3 describes the data and the main empirical results. Section 4 presents additional tests and Section 5 discusses the study's contribution and the implications of its findings.

2. Research Design

2.1. Measuring the stock market response to forecast revisions

We measure investor response to forecast revisions by the three-day (–1, 0, +1) mean cumulative size-adjusted return (SAR_{ijt}) surrounding analyst *i*'s earnings forecast revision for firm *j* in year *t*. The cumulating period starts in day –1 and ends in day +1 where day 0 is the forecast revision announcement date and days –1 and +1 are trading days. *SARs* are calculated as the difference between the buy-and-hold return of the firm and the buy-and-hold return of an equal-weighted portfolio of firms in the same NYSE decile.

2.2 Tests of stock market response to forecast revisions

Previous research has shown that the market reaction to forecast revisions varies with analyst characteristics and forecast features that are associated with forecast accuracy (Abarbanell, Lanen and Verrecchia, 1995, Clement and Tse, 2003; Bonner et al., 2003). To examine the extent to which investors use rounding relative to other characteristics in responding to analyst forecast revisions, we use the following model:

$$SAR_{ijt} = \alpha + \beta REVP_{ijt} * ROUND_{ijt} + \delta ROUND_{ijt} + \sum_{k} \theta_k \, REVP_{ijt} * Analyst\_characteristics_{ijt} + \mu Analyst\_characteristics_{ijt} + \varepsilon_{ijt} \quad (1)$$

The variable definitions in the model are as follows. SAR_{ijt} is the three day size-adjusted return defined above. $REVP_{ijt}$ is analyst *i*'s forecast revision for firm *j* in year *t* scaled by closing stock price two days prior to the revision. The forecast revision is the difference between analyst *i*'s latest forecast outstanding at the earnings announcement date and analyst *i*'s most recent prior forecast.[8] $ROUND_{ijt}$ is an indicator variable equal to 1 if the analyst *i*'s latest forecast for firm *j* in year *t* outstanding at the earnings announcement date in year *t* (hereafter *current* forecast) ends in zero or five; and 0 otherwise. $REVP_{ijt}$ *$ROUND_{ijt}$ measures the differential market response to rounded forecasts compared to non-rounded forecasts. The remaining interaction terms $REVP_{ijt}$ *$Analyst\_characteristics_{ijt}$ capture the investor response variation with each of the analyst characteristics. These characteristics include features associated with forecast accuracy (Mikhail, Walther and Willis, 1997; Clement, 1999; Jacob, Lys and Neale, 1999; Brown, 2001; Brown, 1991; Brown and Mohd, 2003, Clement and Tse, 2003)

[8] Our choice of the forecast revision measurement as the difference between the analyst's current and prior forecast is consistent with prior literature (Gleason and Lee, 2003; Stickel, 1991; Imhoff and Lobo, 1984). We also follow previous literature (Herrmann and Thomas 2005; Dechow and You, 2012) in focusing on the latest analyst forecast outstanding at the earnings announcement date.

and with the likelihood of rounding (Herrmann and Thomas, 2005), namely, forecast horizon, prior forecast accuracy, broker size, firm experience, forecast frequency, number of days elapsed since the prior forecast, number of companies and number of industries that the analyst follows. Consistent with prior evidence, we expect investor response to increase with prior forecast accuracy, broker size, forecast frequency, and firm experience and to decrease with the forecast horizon, days elapsed since the last forecast and the number of companies and industries followed. If investors react to rounding in analyst forecasts as if it is an indicator of less precise forecasts, we expect the coefficient on the interaction term *REVP*ROUND* to be negative and significant.

To enable comparisons between investor weights on analyst characteristics and to assess the relative importance of rounding in explaining investor response, we estimate equation 1 with all analyst characteristics defined as indicator variables like *ROUND*. We set each variable to be equal to 0 (1) when its value is below (above) the yearly median.[9]

To test how the market response to analyst forecast revisions varies with rounding repetition, we estimate equation (1) by splitting rounded forecasts (*ROUND* = 1) into two groups depending on repetition: repeated rounding (*REPEATED_ROUND*) and one-time rounding (*ONE-TIME_ROUND*). *REPEATED_ROUND* is an indicator variable equal to 1 when an analyst report contains a rounded current forecast for firm *j* in time *t* (*ROUND = 1*) and a rounded previous forecast and/or rounded one-year-ahead forecast, 0 otherwise. *ONE-TIME_ROUND* is an indicator variable equal to 1 if *only* the current forecast in the analyst report is rounded, 0 otherwise. The previous forecast is the most recent prior forecast that we use in calculating the analyst forecast revision (*REVP*), while the one-year-ahead forecast is the earnings forecast for the subsequent period issued at the same time as the current forecast. We estimate our equations by clustering the standard errors by firm and revision announcement date (similar to Hui and Yeung, 2013) to control for cross-sectional dependence and heteroskedastic and autocorrelated residuals. We also include year fixed effects.

[9] As a robustness test we standardize all variables, including rounding, by subtracting the mean and dividing by the standard deviation of each variable (standard normal distribution). When using this measurement, the coefficients on analyst characteristics reflect the impact of one standard deviation instead of extreme changes in the variables and the relative weights are comparable. The results are qualitatively unchanged.

3. Sample and results

3.1 Sample

We obtain analyst forecasts and actual data on annual earnings per share from the Institutional Brokers Estimate System (I/B/E/S) unadjusted detail file. We use the unadjusted detail tape to avoid a retroactive stock split rounding effect as highlighted by Baber and Kang (2002). Returns data are gathered from the Centre for Research and Security Prices (CRSP) and the rest of the financial variables are obtained from COMPUSTAT. Our sample period starts in 1984, the first year with available analyst forecast data after imposing the sample restrictions, and ends in 2012. Table 1, Panel A, describes the sample selection. Consistent with Herrmann and Thomas (2005) and Dechow and You (2012), we select all available analyst EPS forecasts issued closest to the earnings announcement date. Applying the sample restrictions of these two studies, we delete observations when the forecast horizon in the current year is less than 10 or more than 300 calendar days from the earnings announcement; we require at least two forecasts per analyst; and we retain firms that are followed by at least one analyst that issues rounded forecasts and one analyst that issues non-rounded forecasts. We retain observations with available data on analyst characteristics and three-day cumulative size-adjusted returns. In calculating the returns, we exclude dividend announcements and earnings announcements for the same firm during the three-day revision announcement window to mitigate the effect of confounding events.[10] Finally, we remove observations with fewer than two analysts' forecasts per firm when standardizing analyst characteristics (see footnote 9), and trim forecast revisions at the top and bottom 1%. The final sample consists of 268,970 forecasts, 39,011 firm-years and 7,311 firms.

3.2 Descriptive statistics

Panel B of Table 1 reports the frequency of rounding in analyst forecasts and actual earnings per share. Consistent with previous evidence, rounding is much more prevalent in analyst forecasts (41% of forecasts are rounded (*ROUND* = 1)) than in actual earnings per share (22% of actual earnings are rounded). Almost 79% (=87,317/110,699) of the analysts who issue a rounded current forecast

[10] In the main analysis we do not exclude forecast revisions by other analysts issued in the three-day window, but we exclude them in a robustness test and the results after the exclusion are qualitatively the same.

(*ROUND =1*) also report a rounded previous forecast and/or a rounded one-year-ahead forecast in their report (mean *REPEATED_ROUND* = 32%). Further untabulated analysis shows that the most frequent combination of repeated rounding is that of the current and one-year ahead forecast (in 70% of instances where the current forecast is rounded, the one-year-ahead forecast is also rounded), but cases where all three forecasts, current, previous and one-year ahead, are rounded are also fairly frequent (in 50% of instances where the current forecast is rounded, the previous and the one-year-ahead forecasts are also rounded).

Table 2 presents summary statistics for analyst characteristics. To ensure that our sample is comparable to the samples of previous studies, we standardize the variables used to calculate descriptive statistics in a manner similar to Clement and Tse (2003), Herrmann and Thomas (2005) and Dechow and You (2012).[11] The standardization transforms the original minimum and maximum values of each variable to values of 0 and 1, respectively. Appendix A provides the definitions of the standardized variables in detail. This standardization yields a relative measure of each analyst characteristic among those of all analysts who follow the same firm in the same period, filtering out systematic firm and year differences in the characteristics.[12]

We report the statistics for the standardized variables. The distributions of analyst characteristics in Panel A are comparable to those reported by previous studies (Clement, 1999; Clement and Tse, 2003; Herrmann and Thomas, 2005).[13] In Panel B we report the averages of the standardized analyst characteristics for rounded (*ROUND =1*) and non-rounded (*ROUND* = 0) forecasts and the *t*-statistics and *p*-values for the difference in means. Consistent with Herrmann and Thomas (2005), mean accuracy is significantly lower for rounded than for non-rounded forecasts. Relative to non-rounded forecasts, rounded forecasts seem to be issued earlier in the year and by less active

[11] We obtain qualitatively similar results when we repeat the analysis using analyst characteristics standardized in this way.

[12] For prior forecast accuracy we set the standardized variable to 0 for the least accurate forecast (highest absolute forecast error) and 1 for the most accurate forecast (lowest absolute forecast error) to ensure that the measure of performance increases with forecast accuracy.

[13] Based on raw analyst characteristics (statistics not tabulated), forecasts precede the earnings announcement date by 102 days on average and analysts have on average 4 years of firm specific experience; they follow 9 firms in 4 industries on average and provide about 4 twelve-days-apart forecasts for each firm in a given year. The average broker firm employs 45 analysts.

analysts. We find the greatest differences in means between the samples of rounded and non-rounded forecasts for forecast frequency (−0.072, *p*-value <0.001) and forecast horizon (0.059, *p*-value <0.001). The direction of these mean differences is consistent with rounded forecasts being less accurate.[14]

Panel C of Table 2 reports the Pearson (Spearman) correlations among the variables above (below) the diagonal. As expected, forecast accuracy is negatively correlated with rounding and forecast horizon, and positively correlated with broker size, firm experience and forecast frequency.

3.3 Empirical Results

3.3.1 Stock market response to forecast revisions conditional on rounding

Table 3 reports 3-day mean cumulative size-adjusted returns, *SARs*, around analyst forecast revisions. Panel A confirms previous literature results that good news revisions (*REVP* >0) are associated with positive abnormal returns and bad news revisions (*REVP* < 0) are associated with negative abnormal returns (Gleason and Lee, 2003). Consistent with Stickel (1991), the highest positive and the lowest negative *SARs* are documented for the top 5% and bottom 5% of forecast revisions, respectively (Panel A). To measure the difference in market reaction to rounded and non-rounded forecasts, we condition the returns to positive and negative revisions and the returns to revisions of different magnitude (bottom 5th percentile, 5th to 50th percentile; 50th to 95th and top 5th percentile) on rounding type (Panel B). The main result from panel B is that rounded forecasts are associated with a weaker three-day price response than non-rounded forecasts. On average, firms that have positive (negative) revisions with non-rounded forecasts experience a 3-day return of 1.6% (−1.8%). The 3-day return to firms with positive (negative) revisions where the revised forecast is rounded are significantly smaller in absolute magnitude: 1.3% (−1.3%) respectively. Accordingly, the mean three-day hedge return, calculated as the difference between returns to positive and negative forecast revisions, is significantly smaller for rounded forecasts (2.6%) than for non-rounded forecasts (3.3%). Furthermore, the hedge returns from going long on the top 5% and short on the bottom 5% of forecast revisions are

[14] In additional univariate analysis, consistent with Dechow and You (2012), we find that firms with rounded EPS forecasts have EPS of larger magnitude, lower growth characteristics (e.g. lower stock volume and volatility, higher book to market) and higher business complexity (larger firms with more business segments).

5.9% for non-rounded (2.7% for top 5% minus −3.2% for bottom 5%) forecasts and only 4.1% for rounded forecasts (1.8% for top 5% minus −2.2% for bottom 5%). The weaker investor response to rounded forecasts, captured by the lower absolute returns to rounded than to non-rounded forecasts, is statistically significant across all categories. This initial result is consistent with investors using rounding as a signal of less precise forecasts.

Table 4 presents results on how investor reaction to forecast revisions varies with analyst characteristics including rounding (equation 1). In the first column we include all analyst characteristics except *ROUND*. In this specification, investor response to analyst forecast revisions varies only with four out of the eight analyst attributes: forecast horizon (*FOR_HORIZON_D),* brokerage firm size (*BROKER_SIZE_D),* forecast frequency (*N_FORECASTS_D)* and number of days elapsed since the prior forecast (*DAYS_ELAPSED_D)* as evident from the significant interaction terms of these variables with *REVP*. The results suggest that investors respond more strongly to forecast revisions issued earlier in the year (i.e. with larger forecast horizon), shortly after the last forecast revision (i.e. less days elapsed since the last forecast), and by analysts releasing more frequent forecasts and working for larger brokerage firms.[15] When we add *ROUND* to the rest of the analyst characteristics (second column of regression results), we find that rounding is incrementally significant in explaining stock returns (*REVP x ROUND* coeff. = −0.331, *t*-stat = −10.05). The economic interpretation of this coefficient is that an increase in *ROUND* from 0 to 1 is associated with a 0.331 decrease in the association between *SAR* and *REVP*, i.e. when forecasts are rounded the association between returns and forecast revisions is lower than when forecasts are non-rounded. This is an economically significant effect, given the standard deviation of the association between *SAR* and *REVP*.[16] The other characteristics significantly associated with investor response are: forecast horizon (*REVP*FOR_HORIZON_D* = 0.238, *t*-stat = 5.40), forecast

[15] Clement and Tse (2003) also find that investor response to forecast revisions increases with the forecast horizon although forecast horizon is negatively associated with forecast accuracy. They interpret these results as investors responding more strongly to timely forecasts made earlier in the year despite their relatively lower accuracy. The authors also find that investor response decreases with the number of days elapsed since the last forecast.

[16] To interpret the economic significance of this effect, we consider a one standard deviation change in the association between *SAR* and *REVP* by estimating a simplified version of equation 1 ($SAR_{ijt} = \alpha_1 + \beta_1 REVP_{ijt} + \varepsilon 1$ (untabulated) (Francis and Martin, 2010; Kravet, 2014). A one standard deviation decrease in β_1 (0.07) is associated with a decrease in *ROUND* of −0.211 = (0.07/−0.331)*1. Compared to the standard deviation of *ROUND* (0.492 from Panel A, Table 2), this effect is economically significant.

frequency (*REVP*N_FORECASTS_D*=0.204, *t*-stat = 5.76), number of days elapsed since the last forecast (*REVP*DAYS_ELAPSED_D* = −0.167, *t*-stat = −4.08), and broker size (*REVP*BROKER_SIZE_D* = 0.066, *t*-stat = 2.31). The interactions between *REVP* and the remaining four analyst characteristics (prior accuracy, firm experience and number of firms and industries followed) are not significant at the 5% level. Based on these results we can reject H_1, stated in the null. The findings from the multivariate analysis confirm the univariate evidence that when responding to analyst forecast revisions investors react less strongly to rounded than to non-rounded forecasts, consistent with investors using rounding as a proxy for less precise forecasts. One implication of our findings is that investors condition their responses on a subset of more readily observable forecast characteristics, consistent with Clement and Tse (2003) and Bonner et al. (2003) and with previous evidence on limited attention.

3.3.2 Rounding repetition

We next test how the market response to rounding in analyst forecasts varies with rounding repetition. Given that repetition increases the salience of a feature, this is a more powerful test of the salience effect. Table 5, Panel A presents univariate results on differences in cumulative size-adjusted returns between repeated rounding (*REPEATED_ROUND = 1*) and one-time rounding (*ONE-TIME_ROUND =1*). In line with expectations, the returns to repeated rounding are significantly lower in absolute magnitude than the returns to one-time rounding for both good and bad news revisions. The three-day hedge returns (from going long on positive and short on negative revisions) are 2.4% (1.2% to *REVP* > 0 minus −1.2% to *REVP* < 0) to repeated rounding and 3.5% (1.5% to *REVP* > 0 minus −2.0% to *REVP* < 0) to one-time rounding. The difference between the hedge returns to repeated and one-time rounding is significant at the 1% level. These results suggest that investors treat rounded forecasts as even less precise when more than one of the simultaneously disclosed forecasts is rounded relative to when only the current forecast is rounded.

We next estimate equation (1), distinguishing between repeated and one-time rounding. Panel B of Table 5 reports the regression results. The coefficients on the analyst characteristics (not tabulated for brevity) remain qualitatively similar to those in Table 4. The coefficient on *REVP x*

REPEATED_ROUND is negative and significant (coeff. = −0.378, *t*-stat = −11.35) and substantially higher in absolute magnitude than the coefficient on *REVP x ONE-TIME_ROUND*, which is not significant at the 5% level (coeff. = −0.102, *t*-stat = −1.79). The difference in the magnitude of the coefficients on repeated and one-time rounding is statistically significant (χ^2 =22.64, p-value = <0.001). Based on these results we can reject H_2, stated in the null. The findings are consistent with our expectation, and the univariate evidence, that the repetition of rounding enhances its salience and increases investors' perception of rounding as an indicator of less precise forecasts.

3.3.3 Rounding and investor sophistication

We next examine whether the response to rounding varies with levels of investor sophistication. Following prior literature, we use the extent of institutional ownership presence (e.g. Bonner et al., 2003; Hilary and Hsu, 2013) and institutional turnover (Collins et al. 2003) as a proxy for investor sophistication. We first measure the percentage of institutional investor holdings (*INST_HOLDING*) in the firm, based on prior evidence that institutional investors are more sophisticated than retail investors and better able to process available information (Hand, 1990, Boehmer and Kelley, 2009). We distinguish between more and less sophisticated investors by separating the top (fourth) quartile of *INST_HOLDING* (*HIGH_INST_HOLDING)* from the first three quartiles *(LOW_ INST_HOLDING*) of our firm-analyst sample. The sample with available institutional ownership data from Thomson Reuters consists of 183,369 observations over the 1984-2012 period. Average institutional ownership is 88% in the *HIGH_INST_HOLDING* sub-sample and 58% in the *LOW_INST_HOLDING* sub-sample.

Panel A of Table 6 reports the results from the estimation of equation (1) for the *LOW_INST_HOLDING* and *HIGH_INST_HOLDING* sub-samples. The coefficient on *REVP x ROUND* is significantly negative in the *LOW_INST_HOLDING* sub-sample (coeff. = −0.283, *t*-stat = −7.07), but insignificant in the *HIGH_INST_HOLDING* sub-sample (coeff. = −1.140, *t*-stat = −1.33). To test whether the coefficient on *REVP x ROUND* differs statistically between groups, we pool the two sub-samples and introduce a three way interaction between an indicator variable for the *LOW_INST_HOLDING* sub-sample (*LOW_OWN*) and *REVP x ROUND* (untabulated). We also add an interaction between *LOW_OWN* and *REVP* to control for differences in investor response to forecast revisions driven by the level of institutional holdings (Mikhail, Walther and Willis, 2007) and an interaction between *LOW_OWN* and *ROUND* to account for correlation between rounding likelihood and lower institutional holdings (Dechow and You, 2012). The results from this specification yield an insignificant coefficient on *REVP x ROUND (*coeff. = −0.075, *t*-stat = −0.73) and a negative and significant coefficient on *LOW_OWN x REVP x ROUND (*coeff. = −0.240, *t*-stat = −2.19), indicating a significantly different market response to rounding in the *LOW_INST_HOLDING* and *HIGH_INST_HOLDING* sub-samples. As expected, this evidence suggests that the earlier results, consistent with investors using rounding as an indicator of less precise forecasts, are primarily attributed to less sophisticated investors.[17]

Our second measure of investor sophistication is based on institutional investors' trading activity rather than mere ownership, consistent with Collins et al. (2003). Since actively trading institutional investors are more attentive than retail investors to information in earnings-related signals (Hirshleifer, Lim and Teoh, 2011; Collins et al., 2003), the former are likely to attend less to the salience of forecast rounding when responding to analyst forecast revisions. We capture the trading activity of institutional investors directly through their portfolio turnover. We measure institutional investors turnover (*INST_TURNOVER*) based on the churn rates of the firm's institutional holdings, i.e., the average frequency with which institutional investors rotate positions in their portfolios (similar to Gaspar, Massa and Matos, 2005). The calculation of investor turnover rates is a two-stage process. In the first stage we calculate a measure of portfolio turnover for each institutional investor in any given quarter (see Gaspar et al., 2005, p.143). In the second stage we calculate the investor turnover ratio at the firm level by calculating the weighted average of the total portfolio churn rates of firm's institutional investors over the four quarters of each year. The sample with available institutional turnover data consists of 153,654 observations over the 1984-2012 period. We then distinguish between more and less sophisticated investors by separating the top (fourth) quartile of *INST_TURNOVER* in our firm-

[17] Using the sample median of *INST_HOLDING* to distinguish between high and low investor sophistication, we find weaker evidence of differential investor response to rounding (and remaining analyst characteristics) across the two sub-samples. Therefore, the lack of investor response to rounding seems to pertain to the highest levels of investor sophistication, as captured by the top quartile of institutional ownership.

analyst sample (*HIGH_INST_TURNOVER*) from the first three quartiles (*LOW_INST_TURNOVER*). Average investor turnover is 0.372 in the *HIGH_INST_TURNOVER* sub-sample and 0.279 in the *LOW_INST_ TURNOVER* sub-sample. This means that the average firm's institutional investors in the low- (high-) turnover group turn over 14% (19%) of their portfolio in a given quarter and 55% (76%) in a given year, implying an average holding horizon of 22 (16) months.

Panel B of Table 6 reports results from the estimation of equation (1) for the *LOW_INST_TURNOVER* and *HIGH_INST_TURNOVER* sub-samples. The results are qualitatively similar to those in Panel A. The coefficient on *REVP x ROUND* is significantly negative in the *LOW_INST_TURNOVER* sub-sample (coeff. = −0.253, *t*-stat = −6.27), but insignificant in the *HIGH_INST_TURNOVER* sub-sample (coeff. = −0.048, *t*-stat = −0.38).[18] The coefficients on the remaining analyst characteristics (included in the estimation but not tabulated) are similar to those in Panel B, with the exception of broker size, which is significant in explaining returns in the *HIGH_INST_TURNOVER* sub-sample but not in the *HIGH_INST_HOLDING* sub-sample.

In Panel C we examine variation in investor response to rounding repetition. The coefficient on *REVP x REPEATED_ROUND* is negative and significant in the *LOW_INST_HOLDING* sub-sample (coeff. = −0.303, *t*-stat = −7.34) and the *LOW_INST_TURNOVER* sub-sample (coeff. = −0.282, *t*-stat = −6.61), but not significant at the 5% level in the *HIGH_INST_HOLDING* sub-sample (coeff. = −0.219, *t*-stat = −1.84), nor in the *HIGH_INST_TURNOVER* sub-sample (coeff. = −0.056, *t*-stat = −0.42). The coefficient on *REVP x ONE-TIME_ROUND* is negative and significant only in the *LOW_INST_TURNOVER* sub-sample (coeff. = −0.158, *t*-stat = −2.09). This provides some, albeit weak, evidence that the intensifying effect of rounding repetition on the perception of its salience is more pronounced among less sophisticated investors.

[18] To test whether the coefficient on *REVP x ROUND* differs statistically between groups, we pool the two sub-samples and introduce a three way interaction between an indicator variable for the *LOW_INST_TURNOVER* sub-sample (*LOW_TURNOVER*) and *REVP x ROUND* (untabulated). We also add an interaction between *LOW_TURNOVER* and *REVP* and an interaction between *LOW_TURNOVER* and *ROUND*. The results of this specification yield an insignificant coefficient on *REVP x ROUND (*coeff. = −0.029, *t*-stat = −0.23*)* and a negative and significant coefficient on *LOW_TURNOVER x REVP x ROUND (*coeff. = −0.247, *t*-stat = −1.90). These results are consistent with less frequently trading institutional investors using rounding as an indicator of less precise forecasts.

In summary, the results in Table 6 suggest that the market's attention to rounding as a proxy for less precise forecasts pertains to the lower levels of investor sophistication, measured either through institutional shareholder ownership or trading activity. This enables us to reject H_3, stated in the null. The use of repeated rounding as a stronger signal of forecast imprecision is also primarily attributed to investors with lower levels of investor sophistication, corroborating the earlier evidence. These results are consistent with previous evidence that less sophisticated investors are more susceptible to salience effects (Miao et al., 2013).

3.3.4. Rounding and future returns

So far we document a weaker market reaction to rounded compared to non-rounded forecasts, consistent with investors using rounding as a salient indicator of noisier earnings expectations. If investors' use of rounding, and especially of repeated rounding, deters them from fully appraising all remaining informative cues, we expect a delayed market response to the information content of rounded forecasts following the revision announcement. Though the post-revision price drift to analyst forecast revisions is well-established empirically, relatively little is known about the extent to which it is affected by forecast-specific attributes (Gleason and Lee, 2003). Gleason and Lee (2003) find that post-revision announcement returns are associated with subtle aspects of the earnings revision signal (e.g. degree of forecast innovation). We examine whether rounding as a salient forecast-specific feature is also associated with stock returns following the revision announcement.

Similar to Gleason and Lee (2003), we regress future size-adjusted returns over twelve months after the revision announcement, *SAR*s [+2, +253], on a rounding indicator and the remaining factors expected to affect the delayed price response, i.e. revision quantity (price-scaled forecast revision), revision quality (forecast innovation), firm information environment (analyst coverage), and systematic risk factors (firm size, book-to-market ratio, and momentum). We choose this twelve-month-ahead window based on prior evidence of a post-revision drift up to a year after the revision announcement (Stickel, 1991; Gleason and Lee, 2003; Zhang, 2006, etc.), but repeat the analysis using the shorter period between the forecast revision date and the subsequent earnings announcement date. The post-revision drift documented in the prior literature takes the form of higher expected stock returns following good news and lower expected stock returns following bad news. Accordingly, to capture the incremental effect of rounding on future returns, we create a categorical variable, *ROUND_Signal* that is equal to +1 for rounded forecasts with good news (*ROUND* = 1 and *REVP*>0), 0 for non-rounded forecasts, and −1 for rounded forecasts with bad news (*ROUND* = 1 and *REVP*<0). This variable construction implies a long position in firms with rounded good news revisions and a short position in firms with rounded bad news revisions. This approach is consistent with Gleason and Lee's (2003) innovation signal variable construction and reflects our expectation of a delayed market response to the information content of rounded forecasts post-announcement. *Innovation_Signal* controls for the effect of the level of forecast innovation on future returns. It takes the value of +1 (−1) for high innovation good (bad) news and 0 otherwise. Similar to Gleason and Lee (2003), we define forecast revisions as high innovation when the issued forecast is higher (lower) than both the analyst's own prior forecast and the current consensus for good (bad) news. We control for the level of analyst coverage (*Coverage*) that a firm receives using an indicator variable equal to 1 for firms followed by more than the median number of analysts each year, and 0 otherwise. We measure the log of the firm's market capitalization (*Size*) and the book-to-market ratio (*B/M*) at the end of the previous calendar year, and *Momentum* using the firm's market adjusted returns over the twelve months prior to the revision announcement. Consistent with Hui and Yeung (2013), we limit the effect of outliers for these tests by trimming SARs [*+2,+253*], *B/M*, *Size* and *Momentum* at the top and bottom 1%.

Table 7 reports the regression results. In the first column we regress future returns on revision quantity, revision quality, analyst coverage and risk controls. In this specification *REVP* is positively associated with future returns (coeff. = 0.362, *t*-stat = 2.91), consistent with prior evidence of a post-revision announcement price drift. In line with Gleason and Lee (2003), the innovation signal is positively and significantly associated with future returns (coeff. =0.007, *t*-stat = 3.64). In the second column we add the rounding signal variable. The coefficient on *ROUND_Signal* is positive and marginally significant at the 10% level (coeff. 0.003, *t*-stat = 1.95) and that on *Innovation_Signal* remains positive and significant (0.006, *t*-stat = 2.98). This result suggests that rounding helps marginally explain cross-sectional variation in stock returns twelve months after the forecast revision. The relative size of the coefficients suggests that forecast innovation is superior in predicting twelve-month-ahead returns. A hedge strategy based on *ROUND_Signal* yields 0.6% abnormal returns over the next year compared to 1.2% based on *Innovation_Signal*, after controlling for the magnitude of revision, analyst coverage, firm size, book-to-market and momentum.[19] In the next column we repeat the analysis using repeated rounding in place of rounding. The coefficient on *REPEATED_ROUND_Signal* is positive and significant (coeff. = 0.005, *t*-stat = 2.76), and of similar magnitude to that on *Innovation_Signal* (coeff. = 0.006, *t*-stat = 2.98). This result suggests that repeated rounding and forecast innovation have similar ability to explain cross-sectional variations in the post-revision price drift. The more pronounced contribution of *REPEATED_ROUND_Signal* to the post-revision drift than *ROUND_Signal* is consistent with the previously documented significantly lower returns to repeated than to one-time rounding during revision announcements. To rule out a risk-based explanation for the explanatory power of the rounding signal in the post-revision price drift, we examine the three day size-adjusted returns, sorted on the preceding revision sign and rounding feature, around the subsequent earnings announcement date. If the drift is due to a delayed market response, rather than omitted risk variables, then abnormal returns should cluster around earnings announcements when information is released and the market is able to correct for the immediate under-reaction to the forecast revisions. The results show that the three-day hedge returns to positive versus negative forecast revisions for the entire sample, as well as for each rounding category (*ROUND* = 1 and *ROUND* = 0), are consistently positive. Consistent with Gleason and Lee (2003), we interpret this as correction of the market's initial misperception about future earnings around the earnings release date. We document the highest hedge return to repeated rounding (0.344% compared to 0.309% for *ROUND* = 1 and 0.217% for *ROUND* = 0), consistent with the drift being highest for repeated rounding.

Finally, we test a specification where we control for all remaining aspects of the forecast revision, i.e. analyst and forecast characteristics affecting the market response. The results are qualitatively similar both for the rounding (column 4) and for the repeated rounding signal (column 5). Additionally, forecast horizon, prior forecast accuracy and firm experience are positively associated

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[19] Since the estimated coefficients on the signals reflect the average abnormal return to a single position (either long or short), we obtain the average hedge return (i.e. the combination of a long and of a short position) by doubling the coefficient (as in Gleason and Lee, 2003).

with future returns (*FOR_HORIZON_D* coeff. = 0.006, *t*-stat = 1.99, *LAG_ACCURACY_D* coeff. = 0.004, *t*-stat = 1.95, *FIRM_EXP_D* coeff. = 0.009, *t*-stat = 4.74,). These results suggest a delayed market response to less easily observable aspects of forecast revisions, such as the analyst's prior forecast accuracy and firm-specific experience.

Taken together the results in Table 7 provide evidence of a delayed market response to rounded forecasts. Rounding, especially when repeated across the forecasts of the analyst report, is associated with a delayed assimilation of information in analyst forecasts. While this evidence suggests that investors can enhance investment strategies (e.g. Stickel, 1991) by further conditioning the forecast revision on the rounding type, the hedge returns may be difficult to exploit after taking transaction costs into consideration.[20] This is consistent with Mikhail et al., (2004) and Barber, Lehavy, NcNichols and Trueman, (2001) who also find that exploiting the slow market reaction to analyst forecast revisions is unprofitable because of transaction costs. Therefore, we treat the results in Table 7 as completion of the evidence of investor reaction to rounding on the revision announcement date, i.e. an immediate weaker reaction to the information in rounded forecasts is followed by a delayed market response post-announcement.[21] In addition, the evidence on investors' delayed assimilation of information on analyst prior forecast accuracy and firm-specific experience further supports the idea of investors' susceptibility to the salience of rounding and their relative detraction from less easily observable analyst characteristics.

4. Additional analyses

4.1 Firm-level determinants of the decision to round

Herrmann and Thomas (2005) provide evidence that analysts who issue rounded forecasts share the characteristics of less informed analysts (i.e. they have lower prior accuracy, lower forecast frequency,

[20] For a detailed review of the related literature, see Ramnath, Rock, and Shane (2008a).

[21] Mikhail et al., (2004) interpret similar evidence of incomplete market reaction, i.e. a strategy that generates excess returns but is insufficient to cover transaction costs, as consistent with Grossman and Stiglitz's (1980) expanded view of market efficiency: in a competitive and rational economy, information gatherers must earn a return, in expectation, for their search and processing costs.

longer forecast horizon, and larger number of companies/industries followed). Dechow and You (2012) further show that the decision to round is a function of analysts' cost-benefit analysis and is influenced by factors such as EPS magnitude, stock price volatility, trading volume, firm growth, size, and institutional ownership. To control for endogeneity in the rounding choice and mitigate concerns over omitted correlated variables, we run three tests (untabulated). First, we estimate equation (1) by adding firm-fixed effects. The coefficient on *REVP*ROUND* in this specification remains negative and significant. Second, we estimate equation (1) by adding firm characteristics associated with the likelihood of rounding and their interactions with *REVP* as explanatory variables. Consistent with Dechow and You (2012), we include the following firm characteristics: book-to-market ratio, *B/M*, the earnings-to-price ratio, *EP*, the net amount received from external financing activities, *EXFIN*, the number of business segments, *N_SEGMENTS*, the volatility of the firm's returns, *STDRET*, and the firm's trading volume, *TVOL* and interaction terms between these characteristics and *REVP*. *REVP*ROUND* also remains negative and significant in this specification. Third, we perform a propensity score matching analysis that minimizes selection bias related to firm characteristics (Rosenbaum and Rubin, 1983). In the first stage we estimate a logit model to obtain the probability of an analyst issuing a rounded forecast (*ROUND*=1). As discussed above, we include both analyst and firm characteristics in this model. Then we match each rounded forecast to a non-rounded forecast issued by an analyst with the closest propensity score for rounding. We replicate equation (1) for this matched score sample, setting *ROUND* equal to 1 for the treated (rounded forecasts), and 0 for the control observations (non-rounded forecasts). The estimated coefficient on *REVP*ROUND* remains qualitatively unchanged, indicating that investor reaction is weaker to rounded than to non-rounded forecasts. These results mitigate concerns that our earlier findings are affected by selection bias related to firm-specific characteristics.

4.2 Investor reaction to rounding in the presence of a rounded consensus forecast

A potential reason for repeated rounding, especially when the current and the previous forecasts are both rounded (in 59% of instances where the current forecast is rounded, the previous forecast is also rounded) is the presence of a rounded consensus forecast. When the consensus forecast is rounded (in 52% of instances where the current forecast is rounded the consensus forecast is also rounded), analyst rounding may not be related to lower precision; it may simply reflect the market's expectation of rounded EPS in the current period. To address this issue further we perform two tests (untabulated). First, we exclude rounded forecasts that are issued in the presence of a rounded consensus forecast. This also ensures exclusion of rounded forecasts that potentially capture herding behaviour towards a rounded consensus forecast. After excluding these forecasts, the coefficient on *REVP x REPEATED_ROUND* remains negative and significant. Second, we retain all observations and introduce an additional indicator of a rounded consensus forecast (*ROUND_CONS*). In this specification the coefficient on *REVP x REPEATED_ROUND* remains negative and significant. The coefficient on *REVP x ROUND_CONS* is also negative and significant. This result is consistent with investors treating rounded forecasts as less precise even when rounding simply reflects the expectation of rounded EPS.[22]

4.3 If accuracy was all that matters

If accuracy was all that matters, investor response to analyst forecast revisions would have been solely benchmarked against the ability of forecast characteristics to predict future forecast accuracy. As there could be factors other than forecast accuracy that are value relevant, we do not view forecast accuracy as the key benchmark in our main analysis.[23] However, we perform additional analysis using forecast accuracy as a benchmark. Following Clement and Tse (2003), we regress forecast accuracy on all forecast characteristics, including rounding, and then compare the relative investor weights on rounding and the remaining analyst characteristics (Table 4) with the ability of rounding to predict accuracy. When we run the accuracy regression excluding rounding (results not tabulated), we find that all analyst characteristics except broker size are significant in explaining forecast accuracy whereas only a subset of them are significant in explaining returns. This finding suggests that investors condition their

[22] Consensus forecasts are sometimes disclosed in analyst reports. They are more often available on news agency sites like Bloomberg, Reuters and Factset.
[23] For example, investors may respond more strongly to timely forecasts because acting sooner implies larger investing profits (Schipper, 1991), even though these early forecasts are generally less accurate than later forecasts.

responses only on a subset of the factors that predict forecast accuracy, consistent with Clement and Tse (2003) and Bonner et al. (2003) and the evidence on limited attention. When we include rounding in the accuracy regression, forecast horizon and forecast frequency are still the strongest predictors of accuracy, consistent with forecast horizon and forecast frequency having high weights in the returns regression (Table 4). Rounding, however, is among the least important factors in predicting forecast accuracy (along with the number of industries that the analyst follows) even though it has the highest coefficient in explaining the market response. So while investors' weights on less salient forecast characteristics, such as forecast horizon and forecast frequency, are compatible with the high predictive ability of these characteristics for accuracy, investor response to rounding seems very strong relative to the limited incremental ability of rounding to predict accuracy. The inconsistency between investor weights and accuracy weights is even more pronounced when we perform the same analysis for repeated rounding. This result suggests that investors respond to rounding as an indicator of less precise forecasts despite its marginal negative association of rounding with accuracy.

4.4 Robustness tests

We conduct additional robustness tests on the ability of rounding to explain variations in investor response to analyst forecast revisions. First, when estimating the market reaction to rounded forecast revisions (equation 1), we redefine *ROUND* to include cases where both the current and the prior forecast used in the calculation of the revision are rounded whereas in the earlier tests we define *ROUND* on the basis of a rounded current forecast only. We find that the coefficient on *REVP*ROUND* where both the current and prior forecasts are rounded is negative and significant and larger in absolute terms than the coefficient on *REVP*ROUND* where only the current forecast is rounded. This implies that the market reaction is even weaker to rounded forecast revisions and reaffirms the effect of rounding repetition on investor response to analyst forecast revisions.

Second, we include broker firm fixed effects in the regressions to control for the effect of broker firm affiliation on investor reaction to forecast revisions. The main result is qualitatively unchanged with a negative and statistically significant coefficient on *REVP*ROUND*. The earlier evidence of investors' use of rounding is robust to the inclusion of broker firm effects.

Third, we exclude negative forecasts to control for the possibility that the frequency of rounding differs systematically on either side of the zero threshold (Das and Zhang, 2003). The coefficient on *REVP*ROUND* is still qualitatively similar. Finally, we repeat the main analysis by excluding all overlapping forecast revisions (i.e. all forecasts issued in the same announcement window) to isolate the price reaction to non-confounded forecast revisions, consistent with Park and Stice (2000). In the restricted sample (222,448 observations) the coefficient on *REVP*ROUND* remains negative and significant, confirming the robustness of our key results to potentially confounding effects induced from the inclusion of overlapping forecasts.

5. Discussion

We examine investor response to forecast salience, as proxied by rounding. Our results show that investors respond to rounding in a way consistent with it being a proxy for less precise forecasts. Investors' attention to the rounding feature in analyst forecasts manifests itself into a weaker reaction to rounded than to non-rounded forecasts. We find that investors' reaction to rounding is even weaker in the presence of repeated rounding instances and mainly less sophisticated investors appear to use rounding as a signal of less precise forecasts. Finally, we document that rounding and, to a greater extent, repeated rounding in analyst forecasts help explain cross-sectional variation in post-revision announcement stock returns.

Our study makes several contributions to the literature. First, we contribute to the literature on limited attention in capital markets (Hirshleifer and Teoh, 2003; Hirshleifer et al., 2011; Huang et al., 2013; DellaVigna and Pollet, 2013; Clement and Tse, 2003; Johnston, Leone, Ramnath and Yang, 2012; Palomino et al., 2009, etc.) by providing evidence on the variation in investors' response to information salience. To the extent that our evidence is generalizable to other salient forecast features, the results suggest that investors pay attention to salient forecast features, even when these features have limited incremental information content. We also explore the role of repetition of salient features within the same report and provide new evidence that repetition intensifies investor attention to salience. We also shed new light on how investors' reaction to salient forecast characteristics varies by investor type. Existing evidence suggests that disclosure of salient items reduces the information acquisition and attention costs of less sophisticated investors. We show that in the context of salience associated with imprecision and enhanced by repetition, primarily less sophisticated investors appear to rely on salient features when appraising forecasts.

Second, our study contributes to the literature on forecast rounding. Herrmann and Thomas (2005) examine whether capital market expectations are more closely aligned with consensus forecasts that include or exclude rounded forecasts. They show that returns first correlate more with earnings surprises based on expectations including rounded forecasts and then that prices move toward the more accurate forecasts of non-rounding analysts. Dechow and You (2012) further show that investors respond less to unexpected earnings (actual minus forecast earnings) when the forecast is rounded, consistent with a rounded forecast being a noisier proxy of the market's expectation of earnings. Our contribution to these studies is threefold. First, we focus on investor reaction to forecast revisions as opposed to investor reaction to earnings announcements. Individual analyst forecast revisions play an important role in the dissemination of earnings-related information and are more frequent than earnings announcements. Examining investor response to rounding patterns of individual forecast revisions sheds light on the mechanisms by which individual analyst forecasts affect the market expectation of earnings. Second, unlike the two prior studies, we examine investor response to rounding in comparison to other forecast features that explain variation in price reactions to forecast revisions. This helps us assess the relative importance investors place on the rounding feature relative to other forecast attributes. Third, we condition investor reaction to rounding on rounding patterns (i.e. repetition within and across forecasting horizons) and investor type. This sheds light on the factors that explain cross-sectional variation in investor response to rounding.

Finally, our study adds to the literature on investor efficiency in processing analyst forecasts (Hui and Yeung, 2013; Zhang, 2006; Jiang, Lee and Zhang, 2005; Gleason and Lee, 2003; Elgers, Lo, and Pfeiffer 2001; Stickel, 1991, etc.). Gleason and Lee (2003) show that investors mainly appraise the most readily observable subset of informative analyst characteristics when responding to analyst forecast revisions, and as a result price adjustments occur subsequent to the forecast revision date. We contribute to this line of research by documenting that rounding helps explain cross-sectional variations in the post-revision price drift and its association with post-revision returns is comparable in magnitude to that of other forecast characteristics examined by prior literature (e.g. innovation signal by Gleeson and Lee, 2003).

In our analysis we assume that rounding is associated with measurement error. This is a common premise in the psychology, finance and statistics literatures that examine number rounding as a phenomenon. In addition, the accounting literature (e.g., Hermann and Thomas, 2005) and our study, provide evidence of a negative association between rounding and forecast accuracy. There could be an alternative explanation of rounding as well. It is possible that analysts round the revisions of their forecasts to make them more noticeable to investors. The Weber-Fechner law of 'just noticeable differences' suggests that, to be noticeable, the change in a stimulus has to be a constant ratio of the original stimulus. In the context of prices small absolute changes in price are likely to be more noticed by investors when applied to a low price than to a high price (Monroe, 1973). With regard to analyst forecasts, rounding may reflect analysts' attempts to avoid the possibility that the revision goes unnoticed and to signal the direction of change in the forecast to investors. If this is true, rounding need not be associated with measurement error, but instead may represent an attempt to make a signal more noticeable; so that investors react more rather than less to information of rounded forecast revisions. This prediction, however, is not born out in our data. In additional analysis, we find that investor reaction to rounded forecasts revisions is weaker than non-rounded forecast revisions, affirming that investors view rounded forecast revisions as more imprecise.

Our evidence suggests that both analysts and investors fail to understand the costs associated with rounded forecasts. For analysts, the simplicity of avoiding a rounded forecast by adding or subtracting an extra cent implies lack of effort and lack of incentives to be precise (e.g. low trading gain potential on the stock followed). This is consistent with Dechow and You (2012)'s evidence that analysts issue rounded forecasts as a matter of cost-benefit considerations, i.e. when there are low economic incentives to be precise. It is also in line with the evidence provided by Johnston et al. (2012) that due to limited attention and inadequate incentives, analysts do not exert effort to adjust for the 14th week quarter in 53-week years which also has real consequences. Furthermore, analysts may be unlikely to add or subtract a cent to avoid rounded forecasts because doing so may adversely affect their forecast consistency. Hilary and Hsu (2013) show that forecast consistency is much more important than accuracy for analysts' career progression and reputation. Also, in the presence of multiple tasks, analysts may ignore rounding as a signal of lower quality since accuracy in analyst forecasts has a much smaller role in determining their compensation than other factors, such as increase in analyst visibility and customer rating, stock picking, and attracting investment banking business (Groysberg, Healy, and Maber, 2014; Emery and Li, 2009). [24]

From an investor perspective, attending more to salient and easy-to-process forecast features, such as rounding, implies less attention to informationally equivalent or more informative forecast characteristics (e.g. prior forecast accuracy and analyst firm-specific experience). While investors may lose money by ignoring all aspects of the economic environment, inattention to the whole set of available information may be economically justified because time and attention are costly (Hirshleifer and Teoh, 2003). Selective attention is further justified by the vast amount of available information, which increases information processing costs (Kahneman, 1973). Therefore, salience in earnings-related signals may affect investors' assimilation of information given the opportunity cost of time needed to process all informative cues.

Our study unravels an important role for salient cognitive reference points in influencing investor perceptions, which may have important valuation consequences. Although the reported significant effects may appear statistically small, they still have important financial implications. An interesting avenue for further research would be to explore whether firms or analysts strategically use salient cognitive reference points (e.g. focal colours, vertical and horizontal lines) as a way of influencing investor perceptions. Our evidence also reveals an important role for the repetition of salient quantitative information in influencing investor judgements, which would be interesting to investigate further in the context of companies' annual reports. Finally, there is evidence suggesting that analysts tend to neglect relevant financial statement information (e.g., Lys and Sohn, 1990; Abarbanell, 1991; Elgers and Lo, 1994; Abarbanell and Bushee, 1997; Teoh and Wong, 2002). In this regard, it will be

[24] Ramnath, Rock, and Shane (2008b) also argue that systematic errors in analysts' earnings forecasts could be attributed to the inefficient processing of information, or could be due to analysts' incentives. Loffler (1998) concludes that analysts' incentives should be considered in testing for the rationality of earnings forecasts.

interesting to examine analysts' attention to salient earnings-related firm disclosures with varying information content.

Appendix A: Definition of Variables

Variable name	Variable definition
$ACCURACY_{ijt}$	Forecast accuracy measured as the difference between the maximum absolute forecast error for analysts that follow firm *j* in year *t* and the absolute forecast error of analyst *i* following firm *j* in year *t*, scaled by the range of absolute forecast errors for analysts that follow firm *j* in year *t*. The forecast error is the difference between firm *j*'s actual EPS and the last EPS forecast issued by analyst *i* for year *t*, scaled by price at the end of year *t-1*.
$BROKER\_SIZE_{ijt}$	Analyst broker size measured as the difference between the number of analysts in the broker firm employing analyst *i* that follows firm *j* in year *t* and the minimum number of analysts per broker firm employing analysts that follow firm *j* in year *t*, scaled by the range of brokerage size for analysts that follow firm *j* in year *t*.
B/M_{jt}	The book-to-market ratio of firm *j* at the end of year *t*.
_D	Denotes that a variable is defined as an indicator variable, equal to 1 if the value of this variable is greater than the yearly median; 0 otherwise.
$DAYS\_ELAPSED_{ijt}$	Days elapsed since the last forecast measured as the difference between the number of days from analyst *i*'s forecast of firm *j*'s earnings to the most recent forecast for firm *j* in year *t* and the minimum number of days between two adjacent forecasts of firm *j*'s earnings by any two analysts that follow firm *j* in year *t*, scaled by the range of the number of days between two adjacent forecasts of firm *j's* earnings in year *t*.
EP_{jt}	Earnings-to-price ratio, measured as the ratio of earnings per share for firm *j* in year *t* and firm *j*'s price at the end of year *t*.
$EXFIN_{jt}$	Net amount of cash flow received from external (debt and equity) financing activities by firm *j* in year *t* divided by the market value of common equity of firm *j* at the end of year *t*.
$FIRM\_EXP_{ijt}$	Firm experience measured as the difference between the number of years of analyst *i*'s firm *j*-specific experience as of year *t* and the minimum number of years of firm *j*-specific experience for analysts that follow firm *j* in year *t*, scaled by the range of years of firm *j*-specific experience for analysts that firm *j* in year *t*.
$FOR\_HORIZON_{ijt}$	The forecast horizon measured as the difference between the number of days from the forecast issuance date to firm earnings announcement date for analyst *i* following firm *j* in year *t* and the minimum number of days between forecast issuance and earnings announcement for analysts following firm *j* in year *t*, scaled by the range of forecast horizons for analysts following firm *j* in year *t*.
$Innovation\_Signal_{ijt}$	Equals 1 when *Innovation* = 1 and *REVP* >0, −1 when *Innovation* = 1 and *REVP* <0 and 0 when *Innovation* = 0. *Innovation* = 1 when the issued forecast is higher (lower) than both the analyst's own prior forecast and the current consensus for good (bad) news, 0 otherwise.
$INST\_HOLDING_{jt}$	The percentage of shares in firm *j* held by institutions in year *t*.

INST_TURNOVER$_{jt}$	The investor turnover for firm *j* that measures the investment horizon of the firm's institutional shareholders over the four quarters in a year. We first calculate the weighted average of the total portfolio churn rates of the firm's institutional investors over the four quarters in the year as in Gaspar et al. (2005). We obtain the churn rate for each institutional investor and each quarter as follows: $$CR_{it} = \frac{\sum_{j\in Q} \lvert N_{jit}P_{jt} - N_{jit-1}P_{jt-1} - N_{jit}\Delta P_{jt}\rvert}{\sum_{j\in Q} \frac{N_{jit}P_{jt}+N_{jit-1}P_{jt-1}}{2}}$$ where P_{jt} and N_{jit} are the price and number of shares of firm *j* held by institutional investor *i* at the end of quarter *t*. The investor turnover for the firm is then $InvestorTurnover_{kt} = \sum_{j\in S} w_{kit}(\frac{1}{4}\sum_{r=1}^{4} CR_{i,t-r+1})$, where S is the set of shareholders in company *k* and w_{kit} is the weight of investor *i* in the total percentage held by institutional investors at the end of quarter *t*.
Momentum$_{jt}$	Market adjusted returns over the twelve months prior to the revision announcement date (measured as of day -2)
N_FIRMS$_{ijt}$	The size of the analyst portfolio measured as the difference between the number of firms followed by analyst *i* that follows firm *j* in year *t* and the minimum number of companies followed by analysts that follow firm *j* in year *t*, scaled by the range of the number of companies followed by analysts that follow firm *j* in year *t*.
N_FORECASTS$_{ijt}$	Forecast frequency measured as the difference between the number of forecasts issued by analyst *i* for firm *j* in year *t* and the minimum number of firm-*j* forecasts issued by analysts that follow firm *j* in year *t*, scaled by the range of firm-*j* forecasts issued by analysts that follow firm *j* in year *t*.
N_IND$_{ijt}$	The diversity of the analyst portfolio measured as the difference between the number of industries followed by analyst *i* that follows firm *j* in year *t* and the minimum number of industries followed by analysts that follow firm *j* in year *t*, scaled by the range of the number of industries followed by analysts that follow firm *j* in year *t*.
N_SEGMENTS$_{jt}$	The log of 1 plus the number of business segments of firm *j* in year *t*.
ONE-TIME_ROUND$_{ijt}$	An indicator variable equal to 1 if *only* the current forecast in the analyst report is rounded, 0 otherwise.
REPEATED_ROUND$_{ijt}$	An indicator variable equal to 1 when an analyst report contains a rounded current forecast for firm *j* in time *t* (*ROUND = 1*) and a rounded previous forecast and/or rounded one-year-ahead forecast, 0 otherwise.
REPEATED_ROUND_Signal$_{ijt}$	Equals 1when *REPEATED_ROUND* = 1 and *REVP* >0, −1 when *REPEATED_ROUND* = 1 and *REVP* <0 and 0 when *REPEATED_ROUND* = 0.
REVP$_{ijt}$	Forecast revision defined as the difference between the current (latest before the earnings announcement) and previous forecast of analyst *i* for firm *j* in year *t*, scaled by price two days before the announcement of the forecast.

$ROUND_{ijt}$	An indicator variable equal to 1 if analyst *i*'s forecast for firm *j* in year *t* ends in zero or five; 0 otherwise.
$ROUND\_Signal_{ijt}$	Equals 1when *ROUND* = 1 and *REVP* >0, −1 when *ROUND* = 1 and *REVP* <0 and 0 when *ROUND* = 0.
$SARs\ [-1,1]_{ijt}$	The three trading day cumulative size-adjusted return surrounding analyst *i*'s earnings forecast revision for firm *j* in year *t*. The cumulation period starts in day −1 and ends in day +1, where day 0 is the forecast revision announcement date and days −1 and +1 are trading days. *SARs* are calculated as the difference between the buy-and-hold return of the firm and the buy-and-hold return of an equally-weighted portfolio of firms in the same NYSE decile.
SARs [+2,253]	The twelve months cumulative size-adjusted returns subsequent to the analyst *i*'s earnings forecast revision for firm *j* in year *t*. The cumulation period starts in day +2 and ends in day +253, where day 0 is the forecast revision announcement date and days +2 and +253 are trading days. *SARs* are calculated as the difference between the buy-and-hold return of the firm and the buy-and-hold return of an equally-weighted portfolio of firms in the same NYSE decile.
$SIZE_{jt}$	The logarithm of firm *j*'s market capitalization at the end of year *t.*
$STDRET_{jt}$	The standard deviation of firm *j*'s monthly returns over the twelve months preceding the end of year *t*.
$TVOL_{jt}$	The trading volume of firm *j*'s stock over the twelve months preceding the end of year *t*.

Appendix B Extracts from analyst reports

Quarterly and Annual EPS (USD)

	2013	2014			2015			Change y/y	
FY May	Actual	Old	New	Cons	Old	New	Cons	2014	2015
Q1	0.63A	0.86A	0.86A	0.86A	N/A	N/A	0.95E	37%	N/A
Q2	0.57A	0.55E	0.59A	0.58E	N/A	N/A	0.70E	4%	N/A
Q3	0.73A	0.81E	0.73E	0.78E	N/A	N/A	0.89E	0%	N/A
Q4	0.76A	0.88E	0.88E	0.84E	N/A	N/A	0.98E	16%	N/A
Year	2.69A	3.10E	3.05E	3.05E	3.55E	3.55E	3.54E	13%	16%
P/E	29.1		25.7			22.0			

Source: Barclays Research.
Consensus numbers are from Thomson Reuters

Quarterly and Annual EPS (USD)

	2013	2014			2015			Change y/y	
FY May	Actual	Old	New	Cons	Old	New	Cons	2014	2015
Q1	0.63A	0.86A	0.86A	0.86A	N/A	N/A	0.94E	37%	N/A
Q2	0.57A	0.59A	0.59A	0.59A	N/A	N/A	0.71E	4%	N/A
Q3	0.73A	0.73E	0.76A	0.72E	N/A	N/A	0.86E	4%	N/A
Q4	0.76A	0.88E	0.76E	0.81E	N/A	N/A	0.96E	0%	N/A
Year	2.69A	3.05E	2.96E	2.99E	3.55E	3.35E	3.48E	10%	13%
P/E	29.5		26.8			23.7			

Source: Barclays Research.
Consensus numbers are from Thomson Reuters

SGS: Changes to Helvea's estimates (2013-2015)

(In CHF m)	2012	2013E previous	2013E new	2014E previous	2014E new	2015E New
Revenues	5,578	6,130	6,135	6,700	6,662	7,283
Y-o-y growth	16.3%	9.9%	10.0%	9.3%	8.6%	9.3%
Y-o-y organic growth	10.2%	8.9%	8.4%	9.3%	8.5%	9.3%
Y-o-y acquisition growth	4.3%	1.2%	2.1%	0.0%	0.1%	0.0%
Y-o-y currency impact	1.8%	0.1%	–0.5%	0.0%	0.0%	0.0%
Adj. operating income	941	1,052	1,069	1,191	1,207	1,363
Y-o-y growth		12%	14%	13%	13%	13%
Adj. operating margin	16.9%	17.2%	17.4%	17.8%	18.1%	18.7%
Adj. net income	630	738	721	808	819	931
Y-o-y growth		17%	14%	9%	14%	14%
Adj. EPS	82.1	97.5	93.9	106.4	106.6	121.2
Y-o-y growth		19%	14%	9%	14%	14%

Sources: Company data; Helvea estimates

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Table 1

Sample of analyst EPS forecasts and frequency of rounding

This table presents the sample collection process and basic statistics on rounding in analyst forecasts and actual EPS. The sample consists of 268,970 analyst-firm-year observations for the period 1984-2012. *ROUND* is an indicator variable equal to 1 when analyst *i*'s forecast for firm *j* in year *t* is rounded (i.e. ends in zero or five) and 0 otherwise. *REPEATED_ROUND* is an indicator variable equal to 1 when an analyst report contains a rounded current forecast for firm *j* in time *t* (*ROUND = 1*) and a rounded previous forecast and/or rounded one-year-ahead forecast, 0 otherwise. *ONE-TIME_ROUND* is an indicator variable equal to one if *only* the current forecast in the analyst report is rounded, 0 otherwise.

Panel A: Sample selection 1984 - 2012

	Number of analyst forecasts	Number of firm-years	Number of firms
Firm-year-analyst observations (based on last forecast per analyst and firm year)	661,791	101,695	16,659
At least one analyst issuing a rounded forecast and one analyst issuing a non-rounded forecast	501,108	64,721	11,612
Sample with available accounting data and three-day SARs around forecast revisions	286,312	51,056	9,453
Sample after standardization of analyst characteristics (deletion of single analyst observations per firm and year) and trimming of forecast revisions at top and bottom 1%	268,970	39,011	7,311

Panel B: Frequency of rounded forecasts

	Number of forecasts	% of total
Total	268,970	100
Rounded actual EPS	58,003	22
Non-rounded actual EPS	210,967	78
Non-rounded EPS forecasts	158,271	59
Rounded EPS forecast (*ROUND* =1)	110,699	41
REPEATED_ROUND =1	87,317	32
ONE_TIME_ROUND=1	23,382	9

Table 2

Descriptive statistics

This table presents sample descriptive statistics. The sample consists of 268,970 analyst-firm-year observations for the period 1984-2012.

Panel A: This panel presents descriptive statistics of the main variables, calculated over the period 1984-2012. The definitions for the variables are provided in Appendix A.

	Mean	Median	Std. Dev.	25th percentile	75th Percentile
REVP	−0.002	−0.001	0.072	−0.028	0.026
ROUND	0.411	0.000	0.492	0.000	1.000
ACCURACY	0.633	0.778	0.375	0.333	0.979
FOR_HORIZON	0.399	0.292	0.374	0.040	0.739
BROKER_SIZE	0.446	0.379	0.364	0.096	0.791
FIRM_EXP	0.367	0.214	0.397	0.000	0.750
N_FORECASTS	0.430	0.400	0.362	0.000	0.714
DAYS_ELAPSED	0.316	0.118	0.386	0.000	0.588
N_FIRMS	0.391	0.316	0.364	0.000	0.667
N_IND	0.338	0.200	0.373	0.000	0.600
N	268,970				

Panel B: Descriptive statistics (means) of variables by rounding type

	ROUND = 1	*ROUND* = 0	*Diff*	*t*-stat	p-values
REVP	−0.004	−0.003	−0.001	−21.73	<0.001
ACCURACY	0.615	0.646	−0.031	−20.87	<0.001
FOR_HORIZON	0.433	0.375	0.059	40.21	<0.001
BROKER_SIZE	0.447	0.444	0.003	2.34	0.019
FIRM_EXP	0.378	0.358	0.020	12.53	<0.011
N_FORECASTS	0.387	0.459	−0.072	−50.88	<0.001
DAYS_ELAPSED	0.319	0.315	0.004	2.37	0.018
N_FIRMS	0.386	0.394	−0.008	−5.32	<0.001
N_IND	0.338	0.338	0.000	−0.25	0.801
N	110,699	158,271			

Panel C: This panel presents Pearson/Spearman correlation coefficients and *p*-values among the variables above/below the diagonal. The definitions for the variables are provided in Appendix A.

	SARs	*REVP*	*ACCURACY*	*ROUND*	*FOR_ HORIZON*	*BROKER_ SIZE*	*FIRM_EXP*	*N_ FORCASTS*	*DAYS_ ELAPSED*	*N_ FIRMS*	*N_IND*
SARs	1.000	0.138	−0.004	−0.001	−0.012	0.001	0.006	0.006	−0.006	0.000	−0.001
p-value		<0.001	0.063	0.440	<0.001	0.609	0.003	0.002	0.001	0.823	0.507
REVP	0.216	1.000	−0.017	−0.042	−0.020	0.008	0.011	0.047	−0.008	0.010	0.000
p-value	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.815
ACCURACY	0.000	−0.021	1.000	−0.040	−0.293	0.005	0.038	0.160	−0.021	0.026	0.000
p-value	0.837	<0.001		<0.001	<0.001	0.008	<0.001	<0.001	<0.001	<0.001	0.889
ROUND	−0.004	−0.039	−0.028	1.000	0.077	0.005	0.024	−0.098	0.005	−0.010	0.000
p-value	0.058	<0.001	<0.001		<0.001	0.019	<0.001	<0.001	0.017	<0.001	0.801
FOR_HORIZON	−0.006	0.020	−0.235	0.080	1.000	0.003	−0.028	−0.384	−0.081	−0.059	−0.017
p-value	0.004	<0.001	<0.001	<0.001		0.124	<0.001	<0.001	<0.001	<0.001	<0.001
BROKER_SIZE	0.001	0.009	0.015	0.000	0.005	1.000	0.014	0.054	0.044	0.064	−0.022
p-value	0.605	<0.001	<0.001	0.994	0.017		<0.001	<0.001	<0.001	<0.001	<0.001
FIRM_EXP	0.005	0.017	0.031	0.021	−0.018	0.020	1.000	0.019	−0.010	0.071	0.050
p-value	0.008	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001
N_FORECASTS	0.005	0.015	0.158	−0.101	−0.388	0.057	0.027	1.000	0.083	0.063	0.021
p-value	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
DAYS_ELAPSED	−0.002	−0.025	0.002	0.020	−0.089	0.037	−0.013	0.070	1.000	0.018	0.021
p-value	0.391	<0.001	0.438	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	<0.001
N_FIRMS	0.003	0.013	0.036	−0.008	−0.065	0.066	0.084	0.070	0.007	1.000	0.651
p-value	0.118	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001
N_IND	0.001	−0.002	0.013	0.005	−0.027	−0.018	0.064	0.027	0.010	0.653	1.000
p-value	0.735	0.336	<0.001	0.007	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	

Table 3

Three-day mean cumulative size-adjusted returns around forecast revisions by revision sign and magnitude and rounding type

This table presents 3-day (−1, 0, +1) mean cumulative size-adjusted returns (*SARs*) around forecast revisions (*REVP*). Day 0 is the day of the forecast revision and days –1 and +1 are trading days. *SARs* are calculated as the difference between the buy-and-hold return of the firm and the buy-and-hold return of an equally-weighted portfolio of firms in the same NYSE decile. *REVP* is defined as the difference between the current forecast (latest before the earnings announcement) and the previous forecast of analyst *i* for firm *j* in year *t*, scaled by price two days before the announcement of the forecast. Panel A presents *SARs* by *REVP* sign and *REVP* magnitude. Panel B presents *SARs* by *REVP* sign and *REVP* magnitude for rounded and non-rounded forecasts. *ROUND* is an indicator variable equal to 1 when analyst *i*'s forecast for firm *j* in year *t* is rounded (i.e. ends in zero or five) and 0 otherwise. The sample consists of 268,970 analyst-firm-year observations for the period 1984-2012. */**/*** indicate significance at 0.1/0.05/0.01 levels respectively (two-tailed t-test).

Panel A: 3-day *SARs* by revision sign

REVP sign	*REVP* > 0		*REVP* < 0		Difference (REVP > 0 – REVP < 0)
SARs	0.014***		−0.016***		0.031***
N of obs.	123,337		142,864		
REVP magnitude	Top 5%	50% - 95%	5% - 50%	Bottom 5%	Difference (Top % - Bottom 5%)
SARs	0.023***	0.012***	−0.015***	−0.028***	0.053***
N of obs.	13,465	121,180	120,890	13,435	

Panel B: 3-day *SARs* by revision sign for rounded and non-rounded forecasts

REVP sign	*REVP* > 0		*REVP* < 0		Difference (REVP > 0 −REVP < 0)
SARs| ROUND =0	0.016***		−0.018***		0.033***
N of obs.	75,264		81,581		
SARs| ROUND = 1	0.013***		−0.013***		0.026***
N of obs.	48,073		61,283		
Difference (*SARs*|ROUND = 1 – *SARs*|ROUND = 0)	−0.003***		0.004***		
REVP magnitude	Top 5%	50% - 95%	5% - 50%	Bottom 5%	Difference (Top 5% - Bottom 5%)
SARs| ROUND = 0	0.027***	0.013***	−0.017***	−0.032***	0.059***
N of obs.	7,228	72,517	69,575	7,525	
SARs| ROUND = 1	0.018***	0.010***	−0.013***	−0.022***	0.041***
N of obs.	6,207	46,368	50,841	5,940	
Difference (*SARs*| ROUND = 1 – *SARs*|ROUND=0)	−0.009***	−0.003***	0.004***	0.010***	

Table 4

Market reaction to analyst rounding

This table presents estimates from regressions of mean cumulative three-day size-adjusted returns (*SARs*) around forecast revisions on analyst forecast revisions (*REVP*) interacted with *ROUND* and other analyst characteristics. *REVP* is defined as the difference between the current forecast (latest before the earnings announcement) and the previous forecast of analyst *i* for firm *j* in year *t*, scaled by price two days before the announcement of the forecast. *ROUND* is an indicator variable equal to 1 when analyst *i*'s forecast for firm *j* in year *t* is rounded (i.e. ends in zero or five) and 0 otherwise. Appendix A defines the rest of the variables. The *_D* extension denotes the use of indicator variables, set equal to 1 if the underlying forecast or analyst characteristic is above the yearly median, 0 otherwise. The sample consists of 268,970 analyst-firm-year observations for the period 1984-2012. */**/*** indicate significance at 0.1/0.05/0.01 levels respectively (two-tailed). *t*-statistics in parentheses are based on robust standard errors clustered by firm and revision announcement date to control for cross-sectional dependence and heteroskedastic and autocorrelated residuals.

		SARs [−1,1]	*SARs [−1,1]*
	Pred.	Coeff./(*t*-stat)	Coeff./(*t*-stat)
REVP		0.498***	0.645***
		(9.10)	(11.11)
REVPxROUND	−		−0.331***
			(−10.05)
REVPxFOR_HORIZON_D	+	0.222***	0.238***
		(5.02)	(5.40)
REVPxLAG_ACCURACY_D	+	0.003	0.006
		(0.10)	(0.18)
REVPxBROKER_SIZE_D	+	0.066**	0.066**
		(2.28)	(2.31)
REVPxFIRM_EXP_D	+	0.050	0.060*
		(1.52)	(1.82)
REVPxN_FORECASTS_D	+	0.224***	0.204***
		(6.35)	(5.76)
REVPxDAYS_ELAPSED_D	−	−0.165***	−0.167***
		(−4.00)	(−4.08)
REVPxN_FIRMS_D	−	−0.037	−0.036
		(−0.88)	(−0.85)
REVPxN_IND_D	−	0.061	0.070
		(1.38)	(1.61)
ROUND			−0.001***
			(−4.17)
FOR_HORIZON_D		0.001	0.001
		(1.06)	(1.14)
LAG_ACCURACY_D		−0.000	−0.000
		(−0.42)	(−0.41)
BROKER_SIZE_D		0.000	0.000

	(0.88)	(0.89)
FIRM_EXP_D	0.001***	0.001***
	(2.80)	(2.91)
N_FORECASTS_D	0.001***	0.001**
	(2.72)	(2.53)
DAYS_ELAPSED_D	−0.000	−0.000
	(−0.59)	(−0.58)
N_FIRMS_D	−0.000	−0.000
	(−0.41)	(−0.39)
N_IND_D	0.001	0.001
	(1.40)	(1.43)
Constant	0.003***	0.004***
	(2.82)	(3.21)
Year dummies	YES	YES
Observations	268,970	268,970
Adj. R^2	0.0224	0.0235

Table 5

The effect of rounding repetition

Panel A of the table presents differences in cumulative three-day size-adjusted returns (*SARs*) around forecast revisions of repeated and one-time rounding analysts for the period 1984-2012. The differences in *SARs* are calculated separately for positive and negative forecast revisions. *ROUND* is an indicator variable equal to 1 when analyst *i*'s forecast for firm *j* in year *t* is rounded (i.e. ends in zero or five) and 0 otherwise. *REPEATED_ROUND* is an indicator variable equal to 1 when an analyst report contains a rounded current forecast for firm *j* in time *t* (*ROUND = 1*) and a rounded previous forecast and/or rounded one-year-ahead forecast, 0 otherwise. *ONE-TIME_ROUND* is an indicator variable equal to 1 if *only* the current forecast in the analyst report is rounded, 0 otherwise. Appendix A defines the rest of the variables. Panel B presents the results of multivariate analysis. In the interest of brevity, the panel reports the coefficients of the main variables of interest only. The sample consists of 268,970 analyst-firm-year observations for the period 1984-2012. */**/*** indicate significance at 0.1/0.05/0.01 levels respectively (two-tailed). *t*-statistics in parentheses are based on robust standard errors clustered by firm and revision announcement date to control for cross-sectional dependence and heteroskedastic and autocorrelated residuals.

Panel A: Univariate analysis: 3-day size adjusted returns (SARs) by rounding type

	REVP > 0	*REVP* < 0	Difference (REVP > 0 – REVP < 0)
SARs|*ONE-TIME_ROUND* = 1	0.015***	−0.020***	0.035***
N of obs.	11,435	11,947	
SARs| *REPEATED_ROUND* =1	0.012***	−0.012***	0.024***
N of obs.	36,638	49,336	
Difference (*REPEATED_ROUND* =1 – *ONE-TIME_ROUND* = 1)	−0.004***	0.008***	0.016***

Panel B: Multivariate analysis: 3-day size-adjusted returns (*SARs*)

	SARs [−1,1] Coeff./(*t*-stat)
REVP	0.640***
	(11.53)
REVPxREPEATED_ROUND	−0.378***
	(−11.35)
REVPxONE-TIME_ROUND	−0.102*
	(−1.79)
REVP x Analyst characteristics	YES
Analyst characteristics	YES
Year dummies	YES
Observations	268,970
Adj. R^2	0.0230

Table 6

Market reaction to analyst rounding conditional on the level of investor sophistication

This table presents cumulative three-day size-adjusted returns (*SARs*) around forecast revisions for rounded and non-rounded forecasts conditional on measures of investor sophistication. *INST_HOLDING* is the percentage of institutional ownership. The *HIGH_INST_HOLDING* sub-sample includes observations in the top fourth quartile of *INST_HOLDING* and the *LOW_INST_HOLDING* sub-sample includes observations in the first three quartiles of *INST_HOLDING*. *ROUND* is an indicator variable equal to 1 when analyst *i* forecast for firm *j* in year *t* is rounded (i.e. ends in zero or five) and 0 otherwise. *INST_TURNOVER* measures the average investment turnover of the firm's institutional shareholders over the four quarters in the year. The *HIGH_INST_TURNOVER* sub-sample includes observations in the top fourth quartile of *INST_TURNOVER* and the *LOW_INST_TURNOVER* sub-sample includes observations in the first three quartiles of *INST_TURNOVER*. *REPEATED_ROUND* is an indicator variable equal to 1 when an analyst report contains a rounded current forecast for firm *j* in time *t* (*ROUND = 1*) and a rounded previous forecast and/or rounded one-year-ahead forecast, 0 otherwise. *ONE-TIME_ROUND* is an indicator variable equal to 1 if *only* the current forecast in the analyst report is rounded, 0 otherwise. Appendix A provides a detailed definition of all the variables. The *_D* extension denotes the use of indicator variables, set equal to 1 if the underlying forecast or analyst characteristic is above the yearly median, 0 otherwise The sample with available institutional ownership (institutional investor turnover) data consists of 183,369 (153,654) analyst-firm-year observations for the period 1984-2012. */**/*** indicate significance at 0.1/0.05/0.01 levels respectively (two-tailed). *t*-statistics in parentheses are based on robust standard errors clustered by firm and revision announcement date to control for cross-sectional dependence and heteroskedastic and autocorrelated residuals.

Panel A: Multivariate analysis: Investor reaction to forecast revisions across different levels of investor sophistication, measured by the percentage of institutional ownership.

	Pred. Sign	*LOW_INST_HOLDING* *SARs [−1,1]* Coeff./(*t*-stat)	*HIGH_INST_HOLDING* *SARs [−1,1]* Coeff./(*t*-stat)
REVP		0.406***	1.001***
		(6.43)	(4.54)
REVPxROUND	−	−0.283***	−0.140
		(−7.07)	(−1.33)
REVPxFOR_HORIZON_D		−0.082*	−0.288**
		(−1.86)	(−2.08)
REVPxLAG_ACCURACY_D		0.189***	0.161
		(4.00)	(0.94)
REVPxBROKER_SIZE_D		0.041	−0.087
		(1.17)	(−0.74)
REVPxFIRM_EXP_D		0.028	0.180
		(0.90)	(1.62)
REVPxN_FORECASTS_D		0.165***	0.113
		(4.18)	(0.98)
REVP xDAYS_ELAPSED_D		0.069*	0.096
		(1.91)	(1.00)
REVP xN_FIRMS_D		−0.014	−0.134
		(−0.36)	(−0.80)

REVP x N_IND_D	0.068	0.197
	(1.64)	(1.01)
Analyst characteristics	YES	YES
Year dummies	YES	YES
Observations	137,534	45,835
Adj. R^2	0.0175	0.0326

Panel B: Multivariate analysis: Investor reaction to forecast revisions across different levels of investor sophistication, measured by the percentage of investment turnover.

	Pred. Sign	*LOW_INST_TURNOVER* *SARs [−1,1]* Coeff./(*t*-stat)	*HIGH_INST_TURNOVER* *SARs [−1,1]* Coeff./(*t*-stat)
REVP		0.329***	0.918***
		(4.40)	(5.27)
REVP xROUND	−	−0.253***	−0.048
		(−6.27)	(−0.38)
REVP x Analyst characteristics		YES	YES
Analyst characteristics		YES	YES
Year dummies		YES	YES
Observations		115,254	38,400
Adj. R^2		0.0182	0.0321

Panel C: Multivariate analysis: Investor reaction to forecast revisions across different levels of investor sophistication– the role of rounding repetition.

	Pred. Sign	*LOW_INST_ HOLDING SARs [−1,1]* Coeff./(*t*-stat)	*HIGH_INST_ HOLDING SARs [−1,1]* Coeff./(*t*-stat)	*LOW_INST_ TURNOVER SARs [−1,1]* Coeff./(*t*-stat)	*HIGH_INST_ TURNOVER SARs [−1,1]* Coeff./(*t*-stat)
REVP		0.402***	1.013***	0.326***	0.918***
		(6.38)	(4.60)	(4.36)	(5.27)
REVPx REPEATED_ROUND		−0.303***	−0.219*	−0.282***	−0.056
		(−7.34)	(−1.84)	(−6.61)	(−0.42)
REVPx ONE-TIME_ROUND		−0.158**	0.168	−0.065	−0.012
		(−2.09)	(1.13)	(−0.77)	(−0.06)
REVP x Analyst characteristics		YES	YES	YES	YES
Analyst characteristics		YES	YES	YES	YES
Year dummies		YES	YES	YES	YES
Observations		137,534	45,835	115,254	38,400
Adj. R^2		0.0175	0.0329	0.0184	0.0321

Table 7
Future returns and analyst rounding

This table presents regressions of post-revision size-adjusted returns, SARs *[+2,+253]*, on the forecast revision (*REVP*), signals related to the forecast quality, e.g. rounding, level of forecast innovation, analyst characteristics, and risk factors. *ROUND_Signal* equals 1 when *ROUND* = 1 and *REVP* >0, −1 when *ROUND* = 1 and *REVP* <0 and 0 when *ROUND* = 0. *ROUND* is an indicator variable equal to 1 when analyst *i*'s forecast for firm *j* in year *t* is rounded (i.e. ends in zero or five), and 0 otherwise. *REPEATED_ROUND_Signal* equals 1 when *REPEATED_ROUND* = 1 and *REVP* >0, −1 when *REPEATED_ROUND* = 1 and *REVP* <0 and 0 when *REPEATED_ROUND* = 0. *REPEATED_ROUND* is an indicator variable equal to 1 when an analyst report contains a rounded current forecast for firm *j* in time *t* (*ROUND = 1*) and a rounded previous forecast and/or rounded one-year-ahead forecast, 0 otherwise. *Innovation_Signal* equals +1 when *Innovation* = 1 and *REVP* >0, −1 when *Innovation*= 1 and *REVP* <0 and 0 when *Innovation*= 0. *Innovation*= 1 when the issued forecast is higher (lower) than both the analyst's own prior forecast and the current consensus for good (bad) news, 0 otherwise. Appendix A defines the rest of the variables. The *_D* extension denotes the use of indicator variables, set equal to 1 if the underlying forecast or analyst characteristic is above the yearly median, 0 otherwise SARs *[+2,+253]*, *BM*, *Size* and *Momentum* and *REVP* are trimmed at the top and bottom 1%. The sample (after trimming) consists of 248,987 analyst-firm-year observations for the period 1984-2012. */**/*** indicate significance at 0.1/0.05/0.01 levels respectively (two-tailed). *t*-statistics in parentheses are based on robust standard errors clustered by firm and revision announcement date to control for cross-sectional dependence and heteroskedastic and autocorrelated residuals.

	SARs[+2,+253]	*SARs[+2,+253]*	*SARs[+2,+253]*	*SARs[+2,+253]*	*SARs[+2,+253]*
	Coeff./(*t*-stat)	Coeff./(*t*-stat)	Coeff./(*t*-stat)	Coeff./(*t*-stat)	Coeff./(*t*-stat)
Constant	−0.140***	−0.104***	−0.104***	−0.107***	−0.107***
	(−4.70)	(-3.28)	(-3.28)	(-3.37)	(-3.38)
REVP	0.362***	0.344***	0.335***	0.346***	0.337***
	(2.91)	(2.71)	(2.65)	(2.71)	(2.65)
ROUND_Signal		0.003*		0.003*	
		(1.95)		(1.92)	
REPEATED_ROUND_Signal			0.005***		0.005***
			(2.76)		(2.74)
Innovation_Signal	0.007***	0.006***	0.006***	0.006***	0.005***
	(3.64)	(2.98)	(2.84)	(2.91)	(2.76)
Coverage	0.014**	0.014**	0.014**	0.013**	0.013**
	(2.30)	(2.26)	(2.26)	(2.21)	(2.21)
B/M	0.279***	0.288***	0.288***	0.286***	0.286***
	(4.69)	(4.83)	(4.83)	(4.80)	(4.79)
Size	0.006***	0.006***	0.006***	0.006***	0.006***
	(3.49)	(3.54)	(3.55)	(3.36)	(3.36)
Momentum	0.020***	0.020***	0.020***	0.020***	0.020***
	(2.90)	(2.97)	(2.95)	(2.97)	(2.96)
FOR_HORIZON_D				0.006**	0.006**
				(1.99)	(1.99)
LAG_ACCURACY_D				0.004*	0.004*
				(1.95)	(1.95)
BROKER_SIZE_D				0.002	0.002
				(1.10)	(1.10)
N_FORECASTS_D				0.002	0.002
				(1.04)	(1.04)
FIRM_EXP_D				0.009***	0.009***
				(4.74)	(4.74)
DAYS_ELAPSED_D				−0.007***	−0.007***
				(−3.35)	(−3.35)
N_FIRMS_D				0.003	0.003
				(0.98)	(0.97)

N_IND_D				−0.002	−0.002
				(−0.55)	(−0.54)
Year dummies	YES	YES	YES	YES	YES
Observations	248,987	248,987	248,987	248,987	248,987
Adj. R^2	0.0096	0.0098	0.0098	0.0101	0.0101